W H Chappell

FIRST ANNUAL

CIRCULAR

OF

GOODWIN & WEST

MANUFACTURERS OF THE

GOODWIN PUMP,

AND

ADJUSTABLE GRIP PULLEY,

235 First Street, San Francisco.

L. GOODWIN. S. A. WEST.

SAN FRANCISCO:
SPAULDING & BARTO, STEAM BOOK AND JOB PRINTERS,
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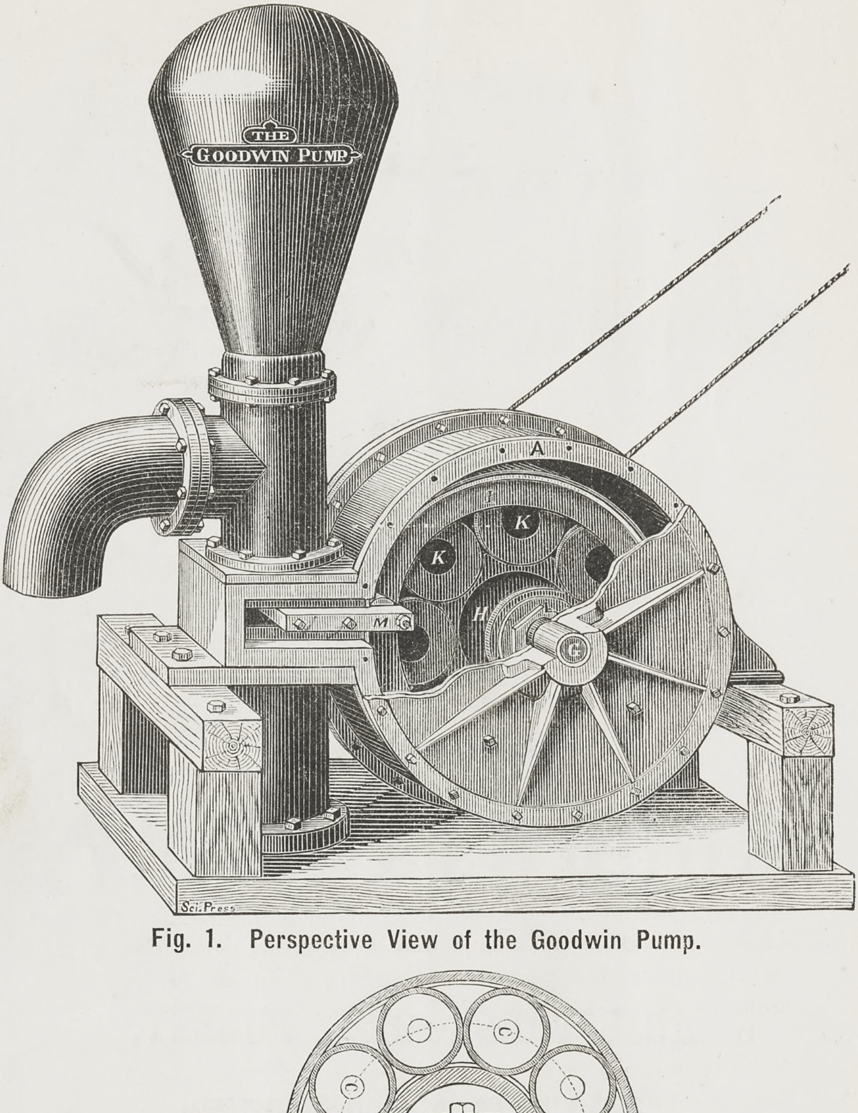

Fig. 1. Perspective View of the Goodwin Pump.

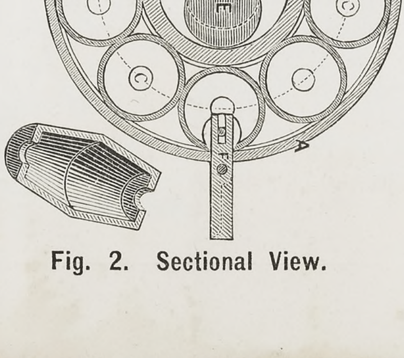

Fig. 2. Sectional View.

The Goodwin & West Pump.

INTRODUCTION.

The proprietors of the Goodwin Pump, in calling the attention of the public to it, do not claim to have discovered any new mechanical principle in hydraulics, nor do they attempt to show how to obtain something for nothing. They will, however, endeavor to demonstrate that it is constructed in strict accordance with well known scientific principles; that unnecessary multiplication of parts has been avoided; that its application of power is simple and direct, that a minimum amount of friction only is generated, while durability, strength, and compactness have not been sacrificed. In the following pages its various sizes and different modifications will be carefully shown, so that any mechanic, skilled in the construction of hydraulic machines, could, by this description alone, manufacture it in all of its variations.

The engravings give even a better idea of its internal arrangement than could be formed by seeing it in actual operation, unless it were taken to pieces and each part examined separately.

The various tables and formula at the end of the circular, furnish all the data required for calculating the speed and size of a pump for any particular purpose or locality, and the amount of power required to drive it.

The memoranda in regard to wire rope will be found useful for reference in many cases where power has to be conveyed to a long distance, and a cheap and simple medium is necessary.

The data for calculation have been prepared with great care, and are believed to be perfectly reliable and in strict accord with the latest deductions of the highest scientific authorities.

Our Double Acting Pump is specially adapted to fire engines and hydraulic mining. As the application of pumps to this branch of mining is in its infancy, we have dwelt upon it at some length.

Pumping by windmills, also, receives considerable attention, owing to their extensive use during the prevalence of the westerly winds in the dry season.

The operation of large pumps for irrigation in the extensive valleys of California and Nevada is fully explained. This is a branch of agriculture in which the Americans are much behind the Mexicans, but the dry seasons of the last few years have forcibly called attention to it, and in the course of a few years the uncertain crops in the Sacramento, San Joaquin, Carson, and Humboldt Valleys will, by the aid of irrigation, become as certain as in those where the soil is naturally better supplied with moisture.

Raising Water from Deep Mines.—This most important branch of pump making has been carefully considered, and the large pumps that we manufacture for this purpose are capable of lifting the water from any depth in a mine. It is only a question of power and of the proper arrangement of the pumps, which we have attempted to fully illustrate. We also manufacture two different kinds of hand pumps—our rotary and a hand plunger.

Thus we flatter ourselves that if any one wants a pump for any purpose to which they are applied, we can supply them; and that all who use pumps will find something to interest them in the following paper.

CIRCULAR

OF

GOODWIN & WEST.

Machines for raising water are amongst the earliest of human inventions. Originally rude, their improvement has kept pace with the advance of civilization, and the best pumps of the present day are among the greatest triumphs of mechanical genius. Few departments of human industry show a more marked improvement than hydraulics. The difference between an Indian canoe and an Ocean steamer is not greater than between the shell of a gourd capable of raising a quart of water, (probably this was the first hydraulic machine), and one of our large pumps, which will raise twenty thousand gallons per minute.

The great superiority of continuous over intermitting movements in nearly all mechanical operations, early led constructors of hydraulic machinery to attempt the making of a device that would yield a continuous stream. This in the chain and pots, and Persian wheel, was partially accomplished; but they would not project a stream of water, and it was not until the cylindrical pump, with an air chamber, was invented, that a continuous stream could be thrown far above the mouth of the orifice from which the water was discharged. This was a very perfect machine, and for ages (it was almost certain that this pump was known to the ancient Egyptians) it stood unrivalled.

It was not until rotary motion was substituted for rectilineal that it found an equal.

Machines that move in right lines of necessity must be recip-

rocating, and consequently their force and velocity must continually vary, and it is not possible to get as high a degree of speed in reciprocating movements as in rotary. This difference is well illustrated in an upright and in circular sawmills, where the continuous cutting rotary saw will do double the work of the upright reciprocating one.

In rapid reciprocating movements the loss of power in overcoming the inertia at each end of the stroke is very great, and the strain in working is more than in rotary movements. The constant tendency of modern mechanics is to substitute continuous for intermitting, and rotary for reciprocating devices, whenever practicable.

The Goodwin Pump is operated by a rotary movement. At the beginning of its stroke, in the single acting variety, the movement of the water is almost imperceptible, gradually increasing it reaches its maximum at the middle of the stroke, and then uniformly diminishes to the end. There is no shock at the commencement of the stroke, as in the cylindrical pump, owing to the action of the valves.

The valve is the soul of most pumps. Except in the Giffard Injector, and a class of centrifugal pumps, the action of the valves controls the working of the pump.

They are made of metal, rubber and leather; but for heavy work in deep mines, or for raising water for the use of a town, a combination of leather and metal is employed. They soon wear and have to be replaced by others, and the principal care of an ordinary pump is keeping the valves and buckets in order. Nearly or quite all of them have a forward movement at the beginning of the stroke, and a backward motion at the end. This motion is shared by the column of water the pump is lifting, no matter what its height, unless it is counteracted by an air chamber.

Another difficulty with a valve is, that when it raises off its seat and the water is passing through, small pieces of wood or gravel get on the seat and prevent the valve from closing, when the water returns, and the stroke is lost. The Goodwin Pump has no valve, and is free from these objections. It cannot be choked in the valve; there is no backward movement, no concussion, and last but not least, no valves to get out of order and be renewed.

The whole pump is metal, and hot or cold liquids can be pumped with equal facility. This, in many manufactures where hot liquors have to be moved, is a matter of considerable importance.

Owing to the strength of the materials of which it is made, and the absence of valves, it can be run at very high degrees of speed. A small model three inches in diameter was run at the rate of thirty-two hundred revolutions per minute. In this instance the cylinder traveled at the rate of twenty-four hundred feet per minute without injury. Though this is a higher degree of speed than is advisable for ordinary work, still it shows the capacity of the pump for rapid movements. A rate of twelve hundred and fifty feet per minute is the average working speed of a cylinder twenty inches in diameter, or two hundred and fifty revolutions.

Figure 1 represents a perspective view of our pump. It is composed of an outer and inner cylinder, with a circular space between them which forms the pump chamber. The outer and immovable cylinder, marked H, constitutes the shell or principal casing of the pump. It is provided with flanges for bolting on the ends or sides of the pump, and for connecting the feed and discharge pipes, and for securing the pump in position, as shown in the cut where it is secured to a wooden frame. This frame is made of different forms to adapt it to the purpose for which the pump is required. The inner cylinder is not shown in this figure, but is marked A in No. 2. It rolls on the inner side of the outer cylinder, and also revolves on its axis. By this arrangement all of the friction between the cylinders is *rolling* instead of *sliding*. The inner cylinder is supported by friction rollers K, K, which revolve on the eccentric H. If the inner cylinder, rollers and eccentric were composed of one piece, the friction would not only be sliding, but the wear would be at the point of the eccentric, which would soon become loose and allow the water to pass around it. The eccentric, H, is secured to the shaft, G, by means of gibs, so constructed that any wear between the outer and inner cylinders can be "taken up," and the pump made as tight as is desired. In this manner the pump can be adapted to raising water to different heights so as to insure the least possible amount of friction. A pump to raise water only ten or twenty feet, can be comparatively loose ; but

when it has to be raised one or two hundred feet, the parts must fit much closer, to prevent leakage. To secure the ends or sides in close contact, the adjustable ring, I, is provided with screws, so that it can be made as tight as is desired. In this manner all of the wear of the pump can be "taken up," and after it has been run for years it will be just as efficient as when new. The butment, M, is to close, or to form one end of the pump chamber, and prevent the water in the suction pipe from mingling with that in the discharge. Were it not for this the water in the pump would not be discharged, excepting what would be thrown out by centrifugal force, but would revolve in the pump, producing no useful effect. The butment is attached to the inner cylinders by rollers, as is shown in fig. 2 at F, which travel in slots as indicated by the dotted line. The butment is provided with an adjustment to "take up" the wear and render the joints sufficiently close. By this device the butment is firmly attached to the cylinder and moves precisely with it, preventing any jar or concussion. Were it not for this the high degree of speed practicable in our pump would be impossible.

The pressure of the water holds the butment closely on its seat, like the slide valve of a steam engine, and like it were the butment not balanced, the pressure on it would be much greater than is necessary to keep it in close contact with the seat, and cause a great expenditure of power in unnecessary friction.

To remedy this difficulty the butment is so constructed as to allow the water to pass under it, except at the necessary points of contact, graduating the pressure to the point required to secure a close contact, and to keep the butment perfectly close as it wears. This is one of the great advantages of the slide-valve, that as it wears, the contact is closer and more perfect than when it is new.

The pump represented in this engraving is single acting, and an air-chamber is required to throw a continuous stream. This, in a double-acting pump is not necessary, as it will throw a uniform stream without an air-chamber.

The pulley, which is one of our adjustable grip pulleys, is not shown in the cut. By using these pulleys, which prevent the rope from slipping, the power applied is only limited by the strength of the rope.

Fig. 2 shows the arrangement of the rollers between the ec-

centric and the inner cylinder. They are hollow, as shown by the opened one allowing the pressure of the water to be as great on the inside as on the outside. The size of the rollers does not increase the throw of the eccentric, and the vertical movement of the cylinder is no more than that of the eccentric. An experiment was made by clamping these rollers so that neither they nor the cylinder could revolve, and the amount of power required to drive it was nearly doubled.

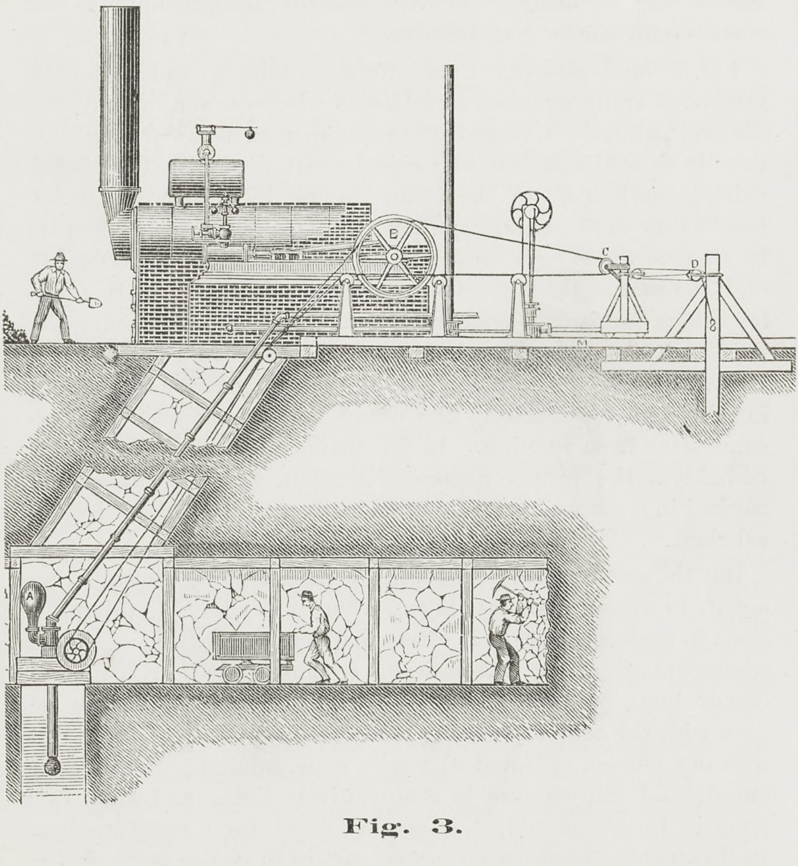

Fig. 3.

Many rotary pumps have been constructed on the principle of the eccentric, but they had no rolling friction; the wear was nearly all on the point of the eccentric, and soon allowed the water to pass between it and the outer cylinder, thus entirely destroy-

ing the effect of the stroke; and as there was no means of taking up the wear they soon became entirely worthless.

There is no principle better established in modern mechanics than that every part of a machine for raising water by forcing, or confining elastic fluids that is subject to wear, must be so constructed that the wear can be "taken up." Unless this can be done, the wear will soon render the machine inoperative. Neglect or inability to comply with this rule, has been the principal reason why so many otherwise skillfully designed pumps and steam engines have been failures.

Fig. 3 represents our Pump for deep mining, and shows the method of applying power by means of wire rope and our adjustable grip pulleys. A, represents the pump in an incline (though it is equally as well adapted to vertical shafts) connected with the driving pulley, B, of the steam engine, by a wire rope which passes over the extending pulley C. This pulley is supported by a frame which rests on the track, M, and can be moved easily on it, so that as the pump is lowered down in the mine this pulley slides forward, obviating the necessity of lengthening the rope each time the pump is lowered, which can be done in a very short time. The pulley, D, is for the purpose of tightening the rope after setting the pump, and whenever it may become slack from running. In this manner the rope can always be held at the proper degree of tension, and a pump can be worked in a crooked shaft or in an incline, as well as in a vertical shaft.

But the greatest advantage will be in conveying power along a drift to work a pump at its end when it is advisable to sink a shaft in such localities. It oftens happens in drifting on a vein when exploring, that it is desirable to sink a shaft or incline at one or more points in the drift; but in wet drifts it cannot be done with the ordinary mining pump without great expense. But with our pumps, operated with wire rope, no difficulty is experienced, and the expense is comparatively light, and when one point is fully explored, it is equally good for testing another. In this manner of applying power, pumps in two or more shafts, at considerable distances apart, can be run by one engine.

Pumps for deep mining have received more careful study than for almost any other purpose, and managers of mines, especially deep and wet ones, have more care on their account than on any

other thing connected with the mine, except perhaps the yield of ore. Our pumps are arranged in lifts one above the other, in the same manner as other pumps. The pump column is the same, and the only difference is in the pump, and applying the power.

HYDRAULIC MINING.

Hydraulic mining is one of the most important branches of gold mining on this coast. In the hydraulic diggings acres on acres of soil and gravel, many feet deep, are washed down to the bed rock; hills, and even mountains, are swept away in a manner resembling the operations of nature more than the work of man.

Where a good head of water can be obtained there is no process at all comparable to this for the economical separation of gold from sand and gravel. Placers that by the old method of working would not pay "board," will, by the power of falling water, yield fortunes to their owners.

Sometimes extensive flats or plains contain a sufficient amount of gold to pay to "hydraulic," but there is no fall; though water is abundant, the necessary power cannot be had. In other cases gravel is found on an isolated mountain, with no ground of superior elevation near it. In many such situations the use of a powerful steam engine and pump that would throw from one to four hundred inches of water per minute, with a pressure of one hundred pounds, would enable the miners to work these deposits as effectually as with a fall of two hundred feet. The friction through long pipes is considerable, and a fall of two hundred and forty feet will give only about one hundred and five pounds pressure at the nozzle. Pumps for deep mining have been in use for ages, but their applications to hydraulic mining is in its infancy, and there is a fine field for experiment and improvement in their construction and application.

In the first place the amount of power exerted by a hydraulic stream is much greater than is generally supposed, and only an accurate calculation will show what it really is. And this power is very uniform. In substituting a pump for fall, these conditions must be strictly complied with. To insure this the pump and engines must have a considerable amount of capacity, more than is ordinarily required; and the pump must be strong, not

liable to get out of order, and throw a stream with an *uniform force*. This last point is of the utmost importance. If the stream is not quite sufficient, either in volume or power, it will not do the work. Though the power and water used are almost as great as in a stream of sufficient force, the effect is not by any means in the same ratio.

In deep mining it has been found advantageous to employ several pumps, one above another, instead of attempting to force the water from the bottom of the mine to the surface at one lift. Though the power is the same or greater in the use of a number of pumps instead of one, the comparatively light strain on each pump is found to be of great advantage. And there is no doubt that an analagous arrangement of pumps, in hydraulic washings, would be found equally as beneficial. By combining three pumps together, one taking the water from another, a pressure of forty pounds imparted by each pump would be equal to one hundred and twenty pounds in the last, or discharging pump, and equal to two hundred and fifty feet of fall, if the conducting pipes are of the ordinary length. Some of the advantages of this system are that the water can be used over again in any place where the water could be collected and pumped back to the forcing pump. Though there are probably few places where this would be practicable, still in some localities it might be done. A steam engine and pump can be moved from one mine to another, and to different parts of the same mine, and they have a portable value, which tunnels, ditches, and flumes have not. These have a value only for the mines for which they are constructed; but if the mine does not pay, they are generally a total loss.

WINDMILL PUMPS.

On this coast, where for a great portion of the year no rain falls, raising water for domestic and agricultural purposes is of much more importance than in the Eastern States, where rain falls with more regularity. Apparently, as a compensation for the scarcity of rain, Nature causes the westerly winds to be both strong and constant, furnishing a cheap and abundant power for the purposes of irrigation. With the reciprocating pumps the great variation in the speed of windmills has been a source of

much difficulty. If the pump is adjusted to the windmill so that it will run with a light breeze, when the wind is very strong

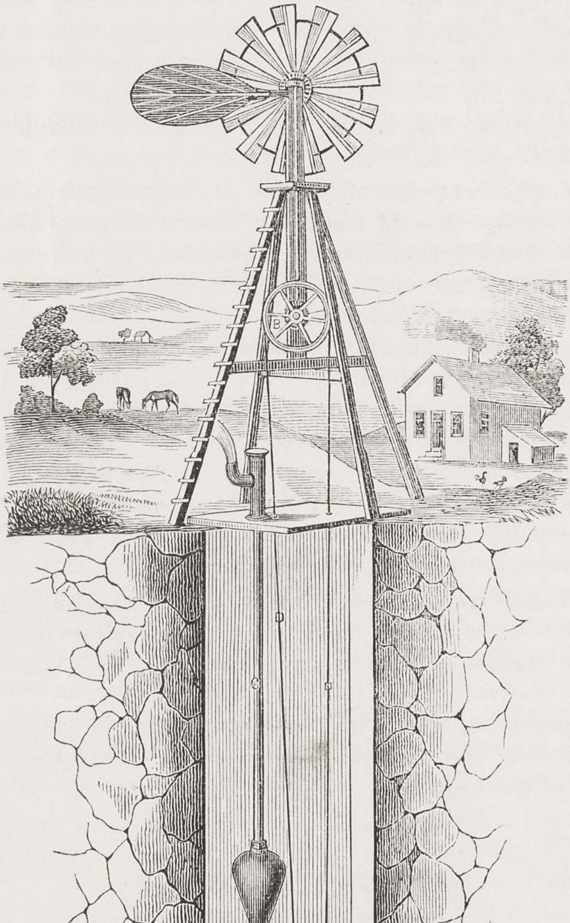

Fig. 4.

it will run at such a speed that it is in danger of breaking; and on the other hand, if the windmill is regulated so that it will not run too fast in a strong wind, in a moderate breeze it will not turn at all. What is required is a pump that can be run efficiently with a light wind and a slow motion, and without change run in a stiff breeze very rapidly and be equally as safe and efficient. In no other way can the full amount of available power given by the windmills be utilized.

Fig. 4, represents one of our pumps designated to be operated by a windmill. It is of a size suitable for a ranch where considerable quantities of water are required for watering stock, and irrigating on a moderate scale. It is much smaller than our large irrigating pumps, but larger than those intended for watering a small garden, or for domestic purposes.

This engraving is so simple that it explains itself, and hardly requires a further description; but we will remark that the windmill is any of the most improved patterns, which by means of gearing transmits power to the pulley, B, from that the power is conveyed to the pulley *b*, by means of the endless wire rope, D, D. The pulley *b* is attached to the pump shaft, and by its rotation forces the water up through the pipe C.

When moderate amounts of water are to be raised to medium heights, a single acting pump is employed, and an air chamber is added to make the flow of water continuous, as is shown in the cut.

This pump can be run from one revolution per minute to fifteen hundred, and the flow of water will be in direct ratio to the number of revolutions.

To insure against loss by slipping of the rope, we employ our adjustable grip pulley, so that all power communicated to the pulley, B, is transmitted to the pump pulley *b*.

Pumps worked in this manner are nearly noiseless, which is often a desideratum in a quiet neighborhood.

The perfect adaptation of the rotary motion of the windmill to the rotary movement of the pump, renders this combination superior to any other in point of efficiency and durability.

Though our pump has good powers of suction, when run at a medium speed, still, if the motion is very slow its power of suction is reduced, and for working by windmills the pump must be set in or near the surface of the water.

IRRIGATING PUMPS.

California and Nevada contain a number of large valleys with rivers of considerable size running through them, as the Sacramento, San Joaquin, Carson, and the Humboldt. In wet or ordinary seasons the moisture is sufficient to insure good crops of grass and grain, but in the exceptional or dry seasons the crops are either very light or a total failure.

To construct ditches, taking water from the rivers, in many cases would be very expensive, especially in the lower part of the valleys, where very large ones would be required, the water moving very slowly. But by the use of large pumps their length could be greatly reduced, and the water taken from a part of the river where there would be no danger of conflict with the rights of other ditch companies, as there usually is, where the river has sufficient fall to admit of the easy construction of ditches.

For this purpose the water would require to be elevated from five to twenty-five feet.

Pumps for this purpose would have to be proportioned to the amount of work to be done. One of the largest size double acting, six feet in diameter, running at the rate of one hundred revolutions per minute, would throw three thousand seven hundred cubic feet, or twenty-three thousand gallons per minute. This would water an acre of ground one inch deep each minute, or fourteen hundred and forty acres per day to the same depth. A steam engine of sixty horse power would be required to raise this amount of water ten feet, and to raise it twenty feet one hundred and twenty horse power would be necessary.

Pumps of this size would fill large ditches, and in a dry season would render thousands of acres of grain productive which otherwise would be a clear loss to the cultivators of the land. When a crop will almost be productive, a small amount of water would be sufficient, and the expense of irrigating would be repaid a hundred fold.

For lands near a river, or where water can be obtained by sinking to a moderate depth, a windmill of large size, or a small steam engine, would water a moderate sized farm, but when a large area is to be irrigated the pump must be in the same ratio.

FIRE ENGINES.

The use of pumps for fire engines is much more ancient than is generally supposed. Ewbank is of the opinion that the Egyptians had fire engines two centuries before Christ, nearly the same as the modern except in the arrangement of the minor details, and there is no doubt that syringes were used many centuries earlier.

These were all worked by hand, and it was not until a comparatively late date, as late as the present generation, that steam was made to do the work of men, and fire was made to control fire.

The modern steam fire engines justly ranks as an invention with the steamboat, locomotive, and electric telegraph. In the construction of steam fire engines, lightness and facility of handling are considerations of prime importance. Durability, which is one of the first requisites in deep mining pumps, in these is subordinate to other considerations, and a Cornish pump in a month does more work than the generality of steam fire engines during their whole existence. This great delicacy is caused by the use of the ordinary pumps on their engines, but with our double acting pump a fire engine can be constructed that will last unimpaired through many years of active service, as a high degree of speed does not injure its efficiency as much as the reciprocating pump. It also throws a more uniform stream, and the air chamber is of much less importance.

OUR ADJUSTABLE GRIP PULLEY.

As wire rope furnishes a very convenient means of applying power to our pump, we have given particular attention to the construction of a pulley that would be reliable in all cases, and equally adapted to different sizes of rope. A round wire rope presents but a small amount of surface in contact with an ordinary pulley. By making the groove in its face in the form of a **V**, the strain on the rope presses on the sides as well as on the bottom, and its adhesive power is much increased. If, in addition to the **V** from, the bottom of the groove is formed of rubber by forcing packing into it, the hold is still farther augmented.

The friction on the sides, however, causes a loss of power and rapidly wears the rope, and probably the loose groove, with a seat of rubber, is preferable to the **V** groove.

To obviate this difficulty, we have constructed an Adjustable Grip Pulley, which we believe fully meets the requirements of the case. It operates on the principle of the inclined plane, and the harder the strain on the rope the more secure and firmly it holds.

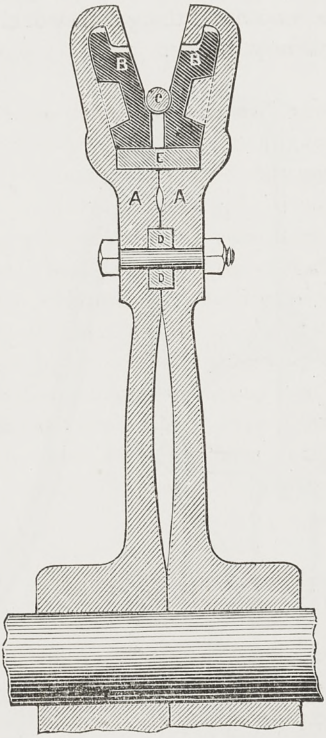

Fig. 5.

Fig. 5 is a sectional view of a part of one of our Adjustable Grip Pulleys. A, A, represents the two sides of the pulley, which are cast separate and firmly bolted together. B, B, are sliders moving on the diagonal sides of the flanges of A, A, and supported by the rubber spring, E. Being set dia-

gonally, as the rope C presses on them they move towards each other, gripping the rope firmly and preventing it from slipping; the greater the pressure the firmer the grip, and when the pressure is removed the hold on the rope is released by the action of the spring E, throwing the sliders B, B, back to their position before coming in contact with the ropes. The adjuster D, D, is placed between the two sides of the pulley, which are bolted against it, and its thickness is proportioned to the size of rope to be used. By means of this adjuster the sliders hold different sizes of rope with equal facility The periphery of the pulley is smooth, and there is no more danger in working or passing near it than from an ordinary pulley.

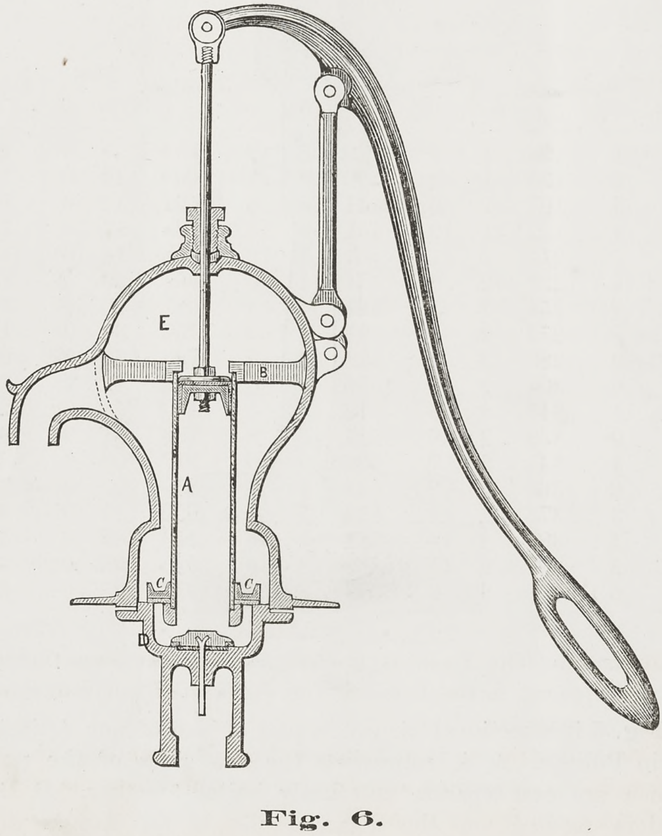

Fig. 6.

Though we give the preference to our rotary pump for general

purposes, still in particular places and for certain purposes, some might desire another form of pump, therefore we give a cut of a reciprocating cylindrical pump. It is made of the best materials and in the most durable manner, and for cheapness and efficiency it cannot be surpassed by any of its class.

Overshot, Breast, and Undershot Water Wheels.

Table of Constants for Estimating the Horses Power of Water Wheels.

Head. Feet.	Head. In.	Constant.	Head. Feet.	Head. In.	Constant.	Head. Feet.	Head. In.	Constant.	Head. Feet.	Head. In.	Constant.
	1	96	1	7	419	3	2	593	9	0	1000
	2	136	1	8	430	3	4	609	10	0	1054
	3	167	1	9	441	3	6	624	12	0	1155
	4	192	1	10	451	3	8	638	14	0	1224
	5	215	1	11	461	3	10	653	16	0	1333
	6	236	2	0	471	4	0	667	20	0	1491
	7	254	2	1	481	4	3	687	25	0	1667
	8	272	2	2	491	4	6	707	30	0	1829
	9	289	2	3	500	4	9	726	36	0	2000
	10	304	2	4	509	5	0	745	49	0	2333
	11	319	2	5	518	5	4	769	64	0	2667
1	0	333	2	6	527	5	8	793	81	9	3000
1	1	347	2	7	536	6	0	817	100	0	3333
1	2	360	2	8	544	6	6	850	121	0	3667
1	3	373	2	9	553	7	0	892	144	0	4000
1	4	385	2	10	561	7	6	913	169	0	4333
1	5	397	2	11	569	8	0	943	196	0	4667
1	6	408	3	0	577	8	6	972	225	0	5000

REMARKS.—The Head is the vertical distance from the center of the opening in the Gate to the surface of the water in the flume or reservoir.

The Fall is the vertical distance from the center of the opening in the Gate to the lower edge of the wheel, less the clearance of from six to twelve inches.

The above table is computed upon the basis that the *experi-*

mental velocity of water flowing out of a comparatively large aperture, is *four-fifths* of its theoretical velocity.

Rule to find the Power of an Overshot or Breast Water Wheel.

Multiply the area of the opening in the Gate in inches by the Fall in feet, and this product by the tabular constant opposite the head, pointing off five figures as decimals.

Example.—The dimensions of the stream are 2 inches by 100 inches, from a head of 2 feet 11 inches. What is its power applied to an overshot water wheel, 40 feet in diameter?

Calculation.—2 inches $\times$ 100 inches $=$ 200 inches opening, 40 feet diameter wheel — 1 foot clearance $=$ 39 feet; tabular constant for head of 2 feet 11 inches $=$ 569; 209 $\times$ 39 $\times$ 569 $=$ 44.38200 horse power. *Ans.*

Rule to find the Power of an Undershot Water Wheel.

Multiply one-half the area of the opening in the Gate in inches by the tabular constant opposite the Head, pointing off five figures as decimals.

Example.—The dimensions of the stream are 4 inches by 150 inches, from a head of 20 feet. What is its power applied to an undershot water wheel?

Calculation.—4 inches $\times$ 150 inches $=$ 600 inches opening; tabular constant for head of 20 feet $=$ 1,491; 1,491 $\times$ 600 $\div$ 2 $=$ 4.37300 horse power. *Ans.*

Memoranda connected with Water.

1 cubic foot of water	= 62. 4 lbs.	
1 cubic inch "	= .036 lbs.	
1 imperial gallon "	= 10 lbs.	
1 American " "	= 8 lbs.	
1 cube foot of water	= 6.2355 gallons.	
or approximately	= 6¼ "	

Table of the Power Required to Raise Water from Deep Wells.

Diameter of Pump Barrel.	Description of Pump.	Quantity of Water raised per hour.	Maximum Depth from which this quantity can be Raised by each Unit of Power.			
			One man turning a Crank.	One donkey working a gin.	One horse working a gin.	One horse power steam engine.
Inches.		Gallons.	Feet.	Feet.	Feet.	Feet.
2	Double Action Lift and Force Pump.	225	80	160	560	880
2½		360	50	100	350	550
3		520	35	70	245	385
3½		700	25	50	175	275
4		900	20	40	140	220

To Find the Effective Power of a High Pressure Steam Engine.

Rule.—Multiply the square of the diameter of the Piston in inches by one-third the product of the number of revolutions, length of stroke in feet, and average pressure of steam in pounds per square inch, pointing off four figures as decimals.

Example.—What is the effective power of an engine, the diameter of the piston being 14 inches, the length of stroke four feet, the average pressure of steam per square inch, 45 pounds, making 40 revolutions per minute ?

Calculation.—$14 \times 14 \times 40 \times 4 \times 45 \div 3 = 47.0400$ horse power. *Ans.*

Animal Power.

Working eight hours per day, in pounds raised one foot per minute.

Horse	21,000	Man, as in rowing	4,000
Mule	18,000	Man, on treadwheel	3,100
Ox	12,000	Man, turning a handle	2,600
Ass	3,500		

Miscellaneous Notes on Water.

A miners' inch is an opening, one inch square through a two inch plank, with a head of water six inches above the opening. A single inch will pass 93 pounds of water in one minute, two inches will pass 196½ pounds in one minute; and where the opening measures 100 inches, each inch will pass 111 pounds per minute.

At the North Bloomfield Gravel Co., the opening is 48 inches long and two inches wide, through two inch plank, with the water nine inches above the center of the opening. Each square inch will pass 4,252½ cubic feet of water in twenty-four hours.

At the Eureka Lake Co. the openings are the same, but the water is six inches above the center of the opening. Each square inch will pass 3,240 cubic feet in twenty-four hours.

At the North Bloomfield Gravel Co. they use a nozzle six inches in diameter, with 240 feet head. The water passes through a pipe 40 inches diameter, 1,200 feet long. The pressure at the pipe is 108 lbs. per square inch, and at the nozzle it is 105 lbs. per square inch. This nozzle passes 1,300 miners' inches in twenty-four hours, or 4,212,000 cubic feet of water in twenty-four hours.

In a flume with a fall of ½ inch to the foot, it takes 7 cubic feet of water to move one cubic foot of hydraulic washings.

Miners' Inches of Water to the theoretical Horse Power with different heads.

Heads in Feet	100	90	80	70	60	50	40	30	20	15	10	5	3	1
Inches to H. P.	3.25	3.61	4.06	4.64	5.41	6.50	8.12	10.8	16.2	21.6	32.5	65.	108.	325.

Round Ropes.

Iron Wire Rope.		Steel Wire Rope.		Hemp Rope.			
Circumference.	Weight per 100 feet in pounds.	Circumference.	Weight per 100 feet in pounds.	Circumference.	Weight per 100 feet in pounds.	Breaking Strain. Tons.	Working Load. Pounds.
$1\frac{3}{4}$	40	$1\frac{1}{2}$	25	3	63	5	1,666
2	52	$1\frac{5}{8}$	33	5	100	7	2,333
$2\frac{1}{4}$	66	$1\frac{7}{8}$	50	$5\frac{1}{2}$	117	$8\frac{1}{2}$	2,666
$2\frac{1}{2}$	83	2	59	6	130	11	3,700
$2\frac{3}{4}$	110	$2\frac{1}{8}$	67	$6\frac{1}{2}$	145	13	4,300
3	139	$2\frac{3}{8}$	83	$7\frac{1}{4}$	185	15	5,000
$3\frac{3}{8}$	170	$2\frac{1}{2}$	91	8	236	19	6,300
$3\frac{3}{4}$	240	$3\frac{1}{8}$	130	9	297	24	8,000
4	260	$3\frac{3}{8}$	153	$9\frac{1}{2}$	330	28	9,400
$4\frac{1}{2}$	285	$3\frac{1}{2}$	166	$10\frac{1}{2}$	428	36	12,000